NAVAL AEROSPACE MEDICAL RESEARCH LABORATORY
51 HOVEY ROAD, PENSACOLA, FL 32508-1046

NAMRL-1382

WORK/REST SCHEDULES AND PERFORMANCE OF S-3 AVIATORS DURING FLEET EXERCISE 1992

David F. Neri and Scott A. Shappell

Approved for public release; distribution unlimited.

Reviewed and approved 15 May 93

A. J. MATECZUN, CAPT, MC USN
Commanding Officer

This research was sponsored by the Naval Medical Research and Development Command under work unit 62233N MM33P30.001-7001 DN477519.

The views expressed in this article are those of the authors and do not reflect the official policy or position of the Department of the Navy, Department of Defense, nor the U.S. Government.

Volunteer subjects were recruited, evaluated, and employed in accordance with the procedures specified in the Department of Defense Directive 3216.2 and Secretary of the Navy Instruction 3900.39 series. These instructions are based upon voluntary informed consent and meet or exceed the provisions of prevailing national and international guidelines.

ABSTRACT

We examined the effect that a fleet exercise has on the work/rest patterns, fatigue, and cognitive performance of S-3 aviators. For 10 days during Fleet Exercise 1992, 21 S-3 aviators from CARRIER AIR WING SEVENTEEN (CVW-17) aboard USS SARATOGA (CV-60) completed detailed daily-activity logs while performing their usual tasks. Subjective measures of fatigue, quality of rest, and sleep need were also collected. A subset of eight aviators completed a brief battery of computer tasks as soon before flying as possible and again after flight debrief. Results indicated that, although the fleet exercise appeared to be below average in difficulty, there were statistically significant performance changes from pre- to postflight on a fatigue-sensitive reaction time task. Average sleep onset was delayed over the course of the fleet exercise, peaking at past 0300 by day 8. A continuation of this pattern could lead to circadian desynchrony and serious sleep problems. Responses to questions on fatigue, sleep need, and readiness to fly a strike mission were consistent with circadian factors. Further research in this area is needed to determine the magnitude and extent of this problem. We recommend that additional data be collected on a variety of fleet exercises with particular effort made to include S-3 squadrons affected by the reductions in manning and increased tasking. The additional data will provide an objective means of fully evaluating the impact of these operational changes on the S-3 community.

Acknowledgments

We thank LT D. Street for serving as a member of the research team. We also thank COMNAVAIRLANT, CVW-17, USS SARATOGA, CDR M. Waack, and especially CDR G. Peterson and the men of VS-30 for their complete cooperation and support.

INTRODUCTION

Ensuring that aircrew continue to perform at peak levels during continuous or sustained combat operations is critical to the success of naval aviation. In addition to its other consequences, combat inevitably affects the sleep/work patterns of naval aviators, sometimes in unanticipated ways (Neri & Shappell, 1992). A predictable result is fatigue and sleep loss. Laboratory studies of sustained performance, fatigue, and sleep loss indicate that performance can degrade in a variety of ways (Angus & Heslegrave, 1985; Angus, Heslegrave, & Myles, 1985; Babkoff, Mikulincer, Caspy, Carasso, & Sing, 1989; Mullaney, Kripke, & Fleck, 1983; Mullaney, Kripke, Fleck, & Johnson, 1983). An ultimate goal of research in sustained/continuous operations is to characterize the type and magnitude of performance degradation under combat conditions and develop suitable countermeasures.

The type and magnitude of the performance degradation of naval aviators during actual combat can best be determined by direct performance measurement at sea during hostilities. Because conflicts are relatively rare and data collection at sea is extremely difficult, there are but a few studies of work/rest patterns, fatigue, combat readiness, and operationally relevant performance of naval aviators under actual combat or near-combat conditions (e.g., Brictson, Hagen, & Wulfeck, 1967; Neri & Shappell, 1992; Shappell & Neri, 1992; Steele, Kobus, Banta, & Armstrong, 1989). A reasonable approach under these circumstances is to collect similar data during training exercises that mimic combat in their operational tempo and tasking. In fact, many training evolutions approach (and some can exceed) certain combat operations in terms of the amount of flying and sleep disruption, if not fear and anxiety.

This study is part of a larger effort to examine the impact of heavy operational tasking on naval aviator work/rest patterns, subjective fatigue, and cognitive performance during both combat and training. Identification of the factors contributing to fatigue can help to determine the steps that can be taken to alleviate it. To obtain a complete picture of the effects of realistic operational tasking, work/rest activity data were collected from all nine squadrons as well as the flight deck crew of the USS SARATOGA (CV-60) during a fleet exercise. Discussions with staff from the Naval Strike Warfare Center and the Center for Naval Analyses resulted in the identification of two communities of aviators warranting detailed examination. These communities were selected because of anticipated heavy tasking both during the fleet exercise and in future scenarios. One group, the F/A-18 community, is explored in a related report (Shappell & Neri, in press). The present paper describes data from an S-3 squadron, which was selected because recent Navy policy dictates that S-3 manning be reduced from 12 crews and 8 aircraft to 9 crews and 6 aircraft. In addition, the availability of new hardware is expected to increase the tasking for this community. For example, S-3 aircrews will be asked to perform more ship search and antisurface warfare (ASuW) missions in addition to their traditional antisubmarine warfare (ASW) role. Even tanking missions are expected to increase in frequency. This decrease in manning and increase in operational tasking may impact aircrew readiness in combat. Objective work/rest and performance data are needed to evaluate the type and degree of any impact on aircrew. A fleet exercise in February 1992 involving CARRIER AIR WING SEVENTEEN (CVW-17) and the USS SARATOGA (CV-60) represented an opportunity to study aviators from the first S-3 squadron to implement these changes in both hardware and manning.

MATERIALS AND METHODS

SUBJECTS

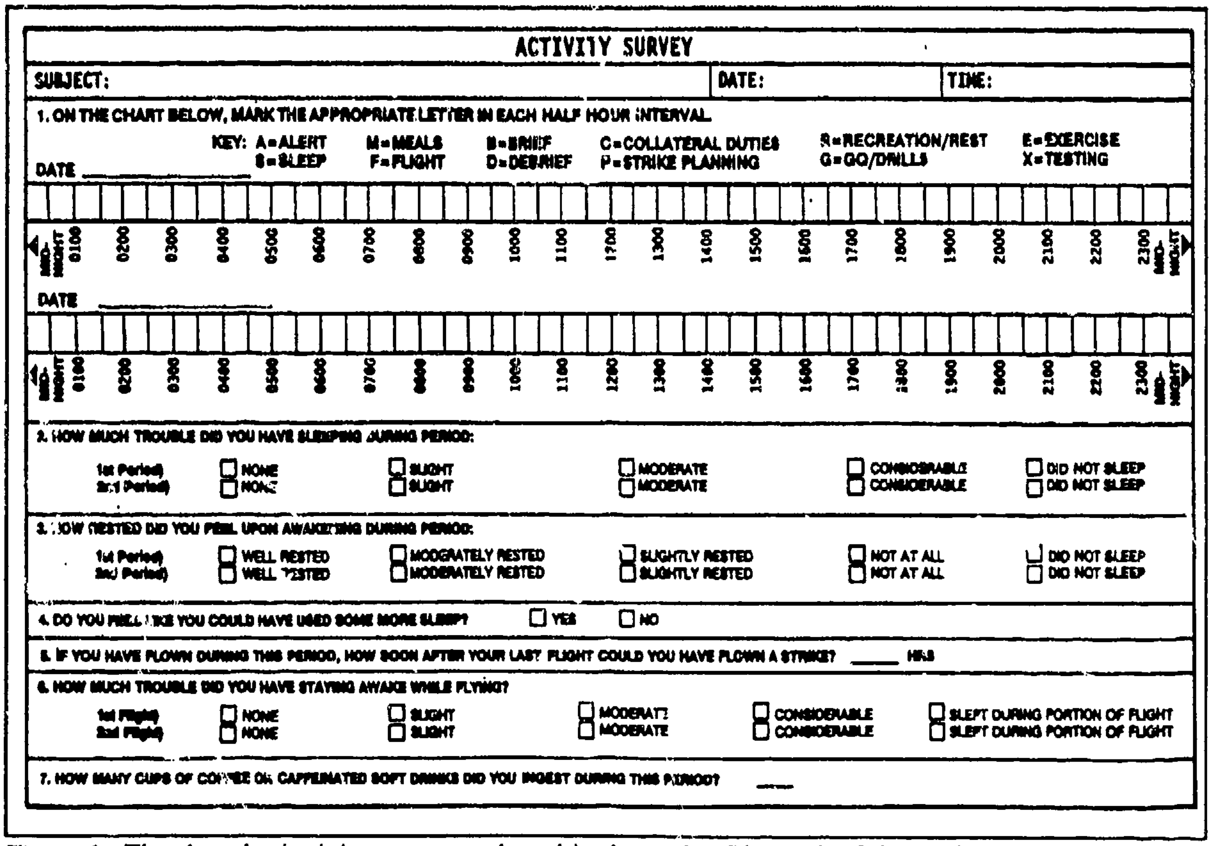
Twenty-one subjects from Air Antisubmarine Squadron THIRTY (VS-30) aboard the aircraft carrier USS SARATOGA volunteered for the study: 5 pilots, 15 naval flight officers (NFOs), and 1 sensor operator. All subjects received a full briefing on the purposes of the study and assurances about the anonymity and confidentiality of the data.

MISSION TASKING

The Lockheed S-3B Viking, successor to the older S-3A, is a carrier-based jet with one pilot and three additional crew members. The S-3B configuration incorporates several improvements in technology over the S-3A. These include the capability of firing antiship Harpoon missiles, an increased radar detection range and classification, and advanced acoustic processing (Anonymous, 1989). Its primary mission is ASW with probable increases in ASuW tasking, as mentioned above.

INSTRUMENT

We used a combination sleep log and activity-survey card (Fig. 1) modeled after Hartman and Cantrell (1967), Storm (1980), and Naitoh, Banta, Kelly, Bower, and Burr (1990), and Neri and Shappell (1992). Logs of this type have been used to predict task performance and mood (Beare, Bondi, Biersner, & Naitoh, 1981) and have been shown to produce reliable sleep measures (Naitoh et al., 1990). The sleep/activity log at the top of the form enables aircrew to record their daily sleep and work activities using the key provided. We customized a set of codes (Table 1) for those activities typically performed by aviators on aircraft carriers. Six additional questions on the lower part of the card pertained to sleep quality, readiness to fly another strike mission, difficulty staying awake in the cockpit, and consumption of caffeine. On the back of each card a subjective questionnaire, the Stanford Sleepiness Scale (SSS), was completed before each flight and after the mission debrief. The SSS is used to determine how sleepy subjects feel (Hoddes, Dement, & Zarcone, 1971). It consists of a series of seven numbered statements ranging from *Feeling active and vital; alert; wide awake* to *Almost in reverie; sleep onset soon; lost struggle to remain awake*.


ACTIVITY SURVEY

SUBJECT: DATE: TIME:

1. ON THE CHART BELOW, MARK THE APPROPRIATE LETTER IN EACH HALF HOUR INTERVAL.

DATE ______ KEY: A=ALERT S=SLEEP M=MEALS F=FLIGHT B=BRIEF D=DEBRIEF C=COLLATERAL DUTIES P=STRIKE PLANNING R=RECREATION/REST G=GO/DRILLS E=EXERCISE X=TESTING

MID-NIGHT 0100 0200 0300 0400 0500 0600 0700 0800 0900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 MID-NIGHT

DATE ______

MID-NIGHT 0100 0200 0300 0400 0500 0600 0700 0800 0900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 MID-NIGHT

2. HOW MUCH TROUBLE DID YOU HAVE SLEEPING DURING PERIOD:

1st Period / 2nd Period: NONE / SLIGHT / MODERATE / CONSIDERABLE / DID NOT SLEEP

3. HOW RESTED DID YOU FEEL UPON AWAKENING DURING PERIOD:

1st Period / 2nd Period: WELL RESTED / MODERATELY RESTED / SLIGHTLY RESTED / NOT AT ALL / DID NOT SLEEP

4. DO YOU FEEL LIKE YOU COULD HAVE USED SOME MORE SLEEP? YES NO

5. IF YOU HAVE FLOWN DURING THIS PERIOD, HOW SOON AFTER YOUR LAST FLIGHT COULD YOU HAVE FLOWN A STRIKE? ____ HRS

6. HOW MUCH TROUBLE DID YOU HAVE STAYING AWAKE WHILE FLYING?

1st Flight / 2nd Flight: NONE / SLIGHT / MODERATE / CONSIDERABLE / SLEPT DURING PORTION OF FLIGHT

7. HOW MANY CUPS OF COFFEE OR CAFFEINATED SOFT DRINKS DID YOU INGEST DURING THIS PERIOD? ____

Figure 1. The sleep log/activity survey card used in the study. The back of the card contained the Stanford Sleepiness Scale.

Table 1. Sleep Log/Activity Survey Code Definitions

Code	Definition
Alert	Alert flight status, ready to launch in relatively short time period
Sleep	Time actually asleep
Meals	Eating
Flight	Time in the aircraft and airborne
Brief	Time spent briefing for the upcoming flight
Debrief	Time spent debriefing after completion of a flight
Collateral duties	All official duties other than flight-related activities
Strike planning	Time spent planning the upcoming mission(s)
Recreation/Rest	Time not flying or working on other official duties
GQ/Drills	Time spent at General Quarters or duties associated with other drills
Exercise	Time spent exercising in stateroom or small workout area
Testing	Not used

PROCEDURES

Work/rest schedules and subjective sleep-related data were collected aboard USS SARATOGA from 31 January through 09 February 1992. The ship was participating in Fleet Exercise 1992 off the coast of Puerto Rico. Subjects completed a separate card for every day of the study, for a maximum of 10 days participation. Subjects filled in the blocks using the first 11 categories listed in Table 1. With 48 blocks per day, a continuous record of daily activity to a resolution of one-half hour was provided for the duration of the fleet exercise.

In addition to completing activity survey cards, eight aviators (3 pilots and 5 NFOs) completed a 5-min battery of computer tasks as soon before flying as possible and again after flight debrief. The task battery was administered to obtain objective, as well as subjective, information regarding the effects of mission tasking on aviator readiness. The battery consisted of a performance test and two subjective inventories. The performance test was composed of blocks 1 and 5 of the Reaction Time (RT) task of the Advisory Group for Aerospace Research & Development (AGARD) Standardized Tests for Research with Environmental Stressors (STRES) Battery (Aerospace Medical Panel Working Group 12, 1989). The subjective tests consisted of the Addiction Research Center Inventory (ARCI) mental efficiency scale (Haertzen, 1966) and the SSS described above.

The RT task has demonstrated sensitivity to fatigue and sleep loss, as well as other factors (Aerospace Medical Panel Working Group 12, 1989). Block 1 is the basic block of trials. Subjects use the index and middle fingers of both hands to press keys on the keyboard in response to stimuli presented on the computer screen. The basic block is a choice reaction time procedure. Any number from 2-5 can appear on the screen, one at a time. If the number appears on the left side of the screen, subjects are instructed to respond with one of the two fingers of their left hand. If the number appears on the right side, they use one of the right-hand fingers. If the number is low (2 or 3) the subjects respond with the left-most finger on the proper hand. If the number is high (4 or 5) they respond with the right-most finger. The numbers are presented for 1 s; the screen then blanks for 1 s. The subject is instructed to respond as soon as he sees the number. Speed of response is emphasized, but not at the expense of accuracy. A feedback message (the word *error*) appears on the screen

when the subject makes an error or fails to respond within 2 s of the presentation of the number. The interval between successive presentations of the numbers is always at least 1 s.

Block 5 is the inverted block. It is similar to the basic block in all ways except the following. Stimuli appearing on the right-hand side of the screen require a left-hand key-press, and stimuli appearing on the left-hand side of the screen require a right-hand key-press. The basic block was always presented first, followed by the inverted block. Trial blocks were about 2 min each in duration and consisted of about 60 trials, depending on the performance efficiency of the subject. Both reaction time and accuracy were recorded by the computer.

The mental efficiency scale of the ARCI consists of a series of 14 statements about physical state (e.g., *My head feels heavy, I feel drowsy*). Subjects reply to the statements by pressing one of two keys on the keyboard corresponding to true and false. The ARCI has been used previously to collect subjective estimates of fatigue during combat (DeJohn, Shappell, & Neri, 1992). The SSS is the same questionnaire completed by aviators on the back of the sleep log/activity survey card.

RESULTS

All data reported here are averages of the responses from the study subjects. Of course, individual responses varied, but our initial interest was in general trends present in the data.

COMPUTER TEST BATTERY

The results from the RT task are shown in Fig. 2. The basic task is presented in the two left panels and the inverted task is presented in the two right panels. No statistically significant differences were obtained between pre- and postflight test sessions on the basic RT task. However, accuracy did change from average to poor, relative to normative data for this test (Aerospace Medical Panel Working Group 12, 1989). The inverted task showed a statistically significant increase in both average RT ($t(51) = -2.96$, $p < .01$) and average error rate ($t(51) = -1.77$, $p < .05$) from pre- to postflight according to a one-tailed, paired-samples t test. The increase in mean RT was from 606 ms preflight to 624 ms postflight. The pre- to postflight mean error-rate increase was from 3.2% to 4.3%.

Because all subjects who participated in the activity survey completed the SSS on the back of the activity cards, SSS data for the computer subjects will not be described separately. The pattern of results is fully consistent with the pattern obtained from the SSS on the back of the activity card and discussed below. The ARCI failed to show significant differences pre- to postflight.

SLEEP LOG/ACTIVITY SURVEY CARD

The onset and duration of the major sleep period are shown in Fig. 3. The major sleep period was defined as that block of time during which the majority of sleep occurred, without regard to time of day. Average onset of the major sleep period is shown in the left panel of Fig. 3. Average sleep onset was never before 0000. For the first 4 days, average onset fluctuated between 0000 and 0100. However, there was a progressive delay in sleep onset through day 8 on which average onset did not occur until *after 0300*. By day 10, sleep onset returned to its lowest level of about 0000. In contrast, average sleep duration did not vary much over the course of the fleet exercise (Fig. 3, right panel). Subjects obtained between 5.5 and 8.0 h of sleep per day during the major sleep period, a range within normal limits.

A summary of several flight- and other sleep-related activities from the activity card is shown in Fig. 4. The categories used in Fig. 4 are defined in Table 2. During the fleet exercise, subjects averaged 2-5 h total flight time per day (Fig. 4, upper left panel). The first day can be discounted because flight quarters were limited in time. Flight-related activities averaged 2-3.5 h per day (upper right panel). Therefore, total time

devoted to flying and flight-related activities was 4-8.5 h in the typical day. Other rest activities (lower left panel) varied from 3-4 h per day during the fleet exercise, showing a generally stable trend. Other work (lower right panel) averaged from 4.5-7.5 h per day, again with no discernable trend over time. Looking at total work time and total sleep/rest time, the average day was split into approximately two equal parts. Work typically encompassed about 13 h per day, leaving about 11 h per day for sleep and other rest and recreation activities.

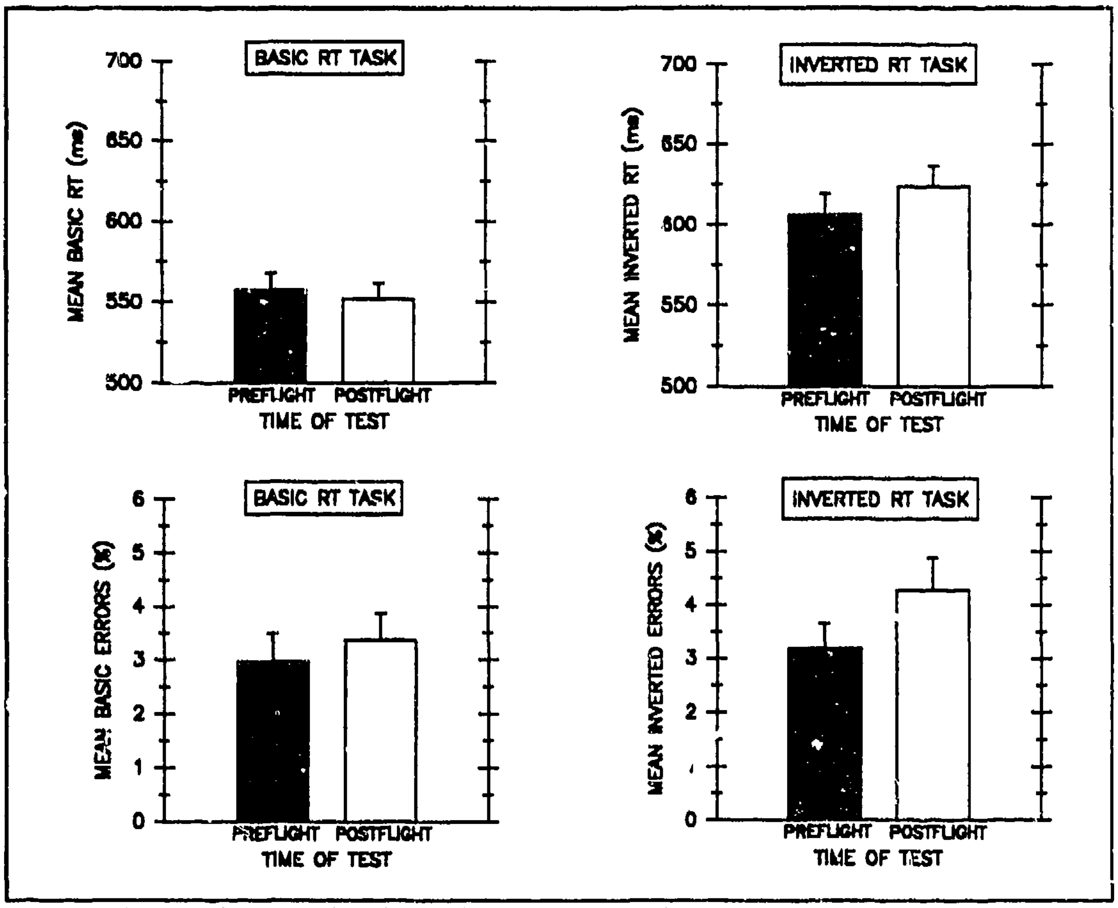


Figure 2. Results from reaction time task. Reaction time is shown in the top panels, errors in the bottom. Error bars are 1 SEM.

The responses to the subjective questions of sleep quality and fatigue are presented in Fig. 5. On the average, subjects reported slight to no trouble sleeping (upper left panel). In fact, average trouble sleeping during the fleet exercise only exceeded ***slight*** once--on day 4. Even for this worst night, sleep trouble averaged only between ***slight*** and ***moderate***. Aviators reported a consistent pattern of restedness (upper right panel) during the fleet exercise. Responses showed little variation from ***moderately rested***. On the other hand, the percentage of responses indicating that more sleep was needed never fell below 50% (lower left panel). Consistent with the sleep trouble results, all subjects reported needing more sleep on day 4. Finally, caffeine ingestion, an admittedly indirect measure of fatigue, is shown in the lower right panel. In general, subjects drank 1-2 cups of caffeinated beverages per day. Consistent with the previous results, caffeine ingestion peaked on day 4. Two subjects were eliminated from this part of the analysis when they reported ingesting more than 15 cups of caffeinated beverages per day (with one instance of 40 cups over a 2-d period).

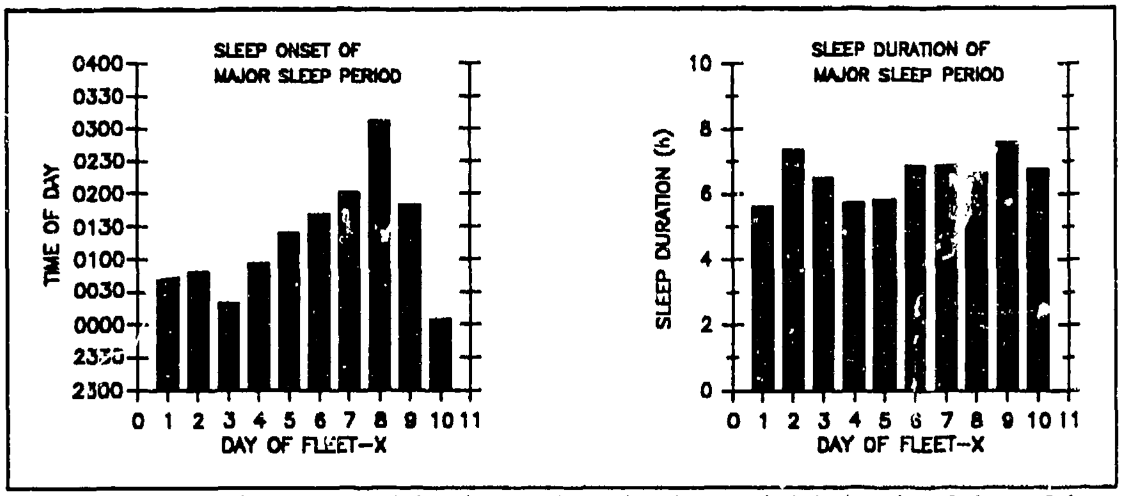


Figure 3. Average sleep onset and duration for the major sleep period during the 10 days of the fleet exercise.

We collected three measures of fatigue associated with flying. The first was obtained from item 5 of the activity card, *If you have flown during this period, how soon after your last flight could you have flown a strike?* This item, referred to as subjective strike delay (SSD), provided an estimate of the time needed before an aviator could fly a combat strike mission at 100% capacity. The SSD results are presented in the upper left panels of Figs. 6 and 7. Consistent with analyses performed on data obtained aboard USS AMERICA (CV-66) during Operation Desert Shield/Storm (Shappell & Neri, 1992), SSD is plotted against both the time the flight was flown (Fig. 6) and flight duration (Fig. 7). The time of day a flight occurred was broken down into four segments of 6 h (Quartile 1 = 0601-1200, Quartile 2 = 1201-1800, Quartile 3 = 1801-0000, and Quartile 4 = 0001-0600). Flights were classified according to which quartile contained the majority of a flight's duration. No consistent differences were obtained in SSD between the first three quartiles, covering 0601-0000, in which SSD averaged 5 h. During 0001-0600, need for additional crew rest increased markedly to more than 8 h. When plotted against flight duration, SSD showed no discernable pattern (Fig. 7). A peak of approximately 8.5 h was associated with the 4.5- and 6-h flights.

The second measure of fatigue associated with flying was obtained from item 6 on the activity card, *How much trouble did you have staying awake while flying?* Because there were few instances of two flights in a day, the results shown in the top right panels of Figs. 6 and 7 are for the first flight of the day only. Aircrew found it easiest to stay awake when airborne during 1201-1800 and 1801-0000, with progressively more trouble during 0601-1200 and 0001-0600, respectively (Fig. 6). Unlike SSD, trouble staying awake varied more regularly with flight duration (Fig. 7). That is, as flight duration increased from 3.5 to 6 h, aviators reported more trouble staying awake, although it never reached even the *slight* level.

The third measure of fatigue associated with flying was obtained from the SSS that was completed pre- and postflight and located on the back of the card. The results are presented in the lower panels of Figs. 6 and 7. The average response varied mostly between *not at peak* and *not at full alertness.* During the 0601-1200 flight quartile, no difference between pre- and postflight was observed (Fig. 6). The results obtained for the remaining three quartiles (1201-1800, 1801-0000, and 0001-0600) showed that levels of sleepiness were higher during postflight than preflight reporting periods. Furthermore, both the pre- and postflight reported levels of sleepiness increased progressively from the second (1201-1800) through the fourth (0001-0600) flight quartiles. The duration of the flight had a marked influence on reported sleepiness as well (Fig. 7). Although the average response only exceeded *not at full alertness* once, a consistent increase was evident postflight relative to preflight. With few exceptions, postflight sleepiness increased progressively with increases in flight duration.

Table 2. Codes Comprising the Activity Categories

Category	Code(s)
Flying	Flight time
Flight-related activities	Briefs, debriefs, alerts
Other rest	Rest, meals, & exercise
Other work	Collateral duties, planning, GQ/drills

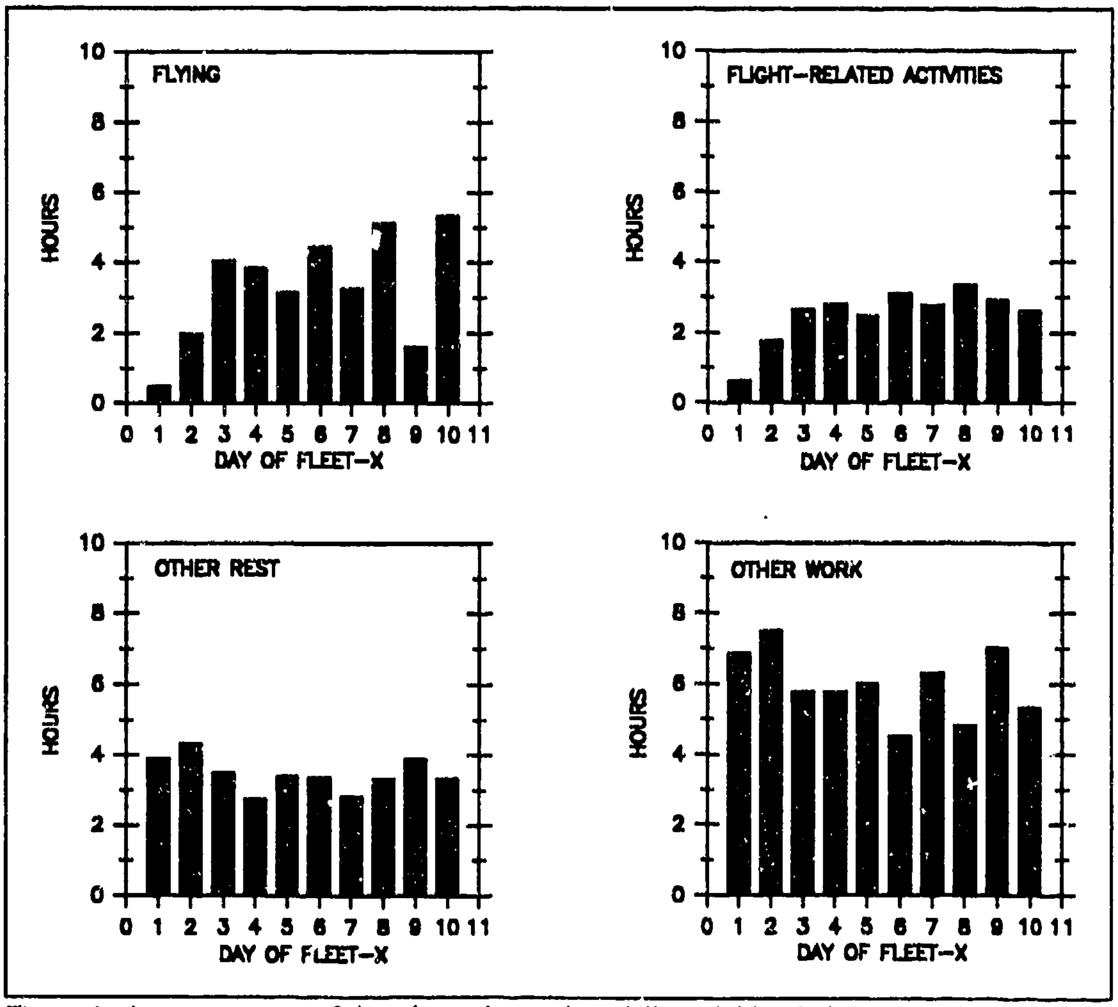


Figure 4. Average amount of time devoted to various daily activities during the 10 days of the fleet exercise.

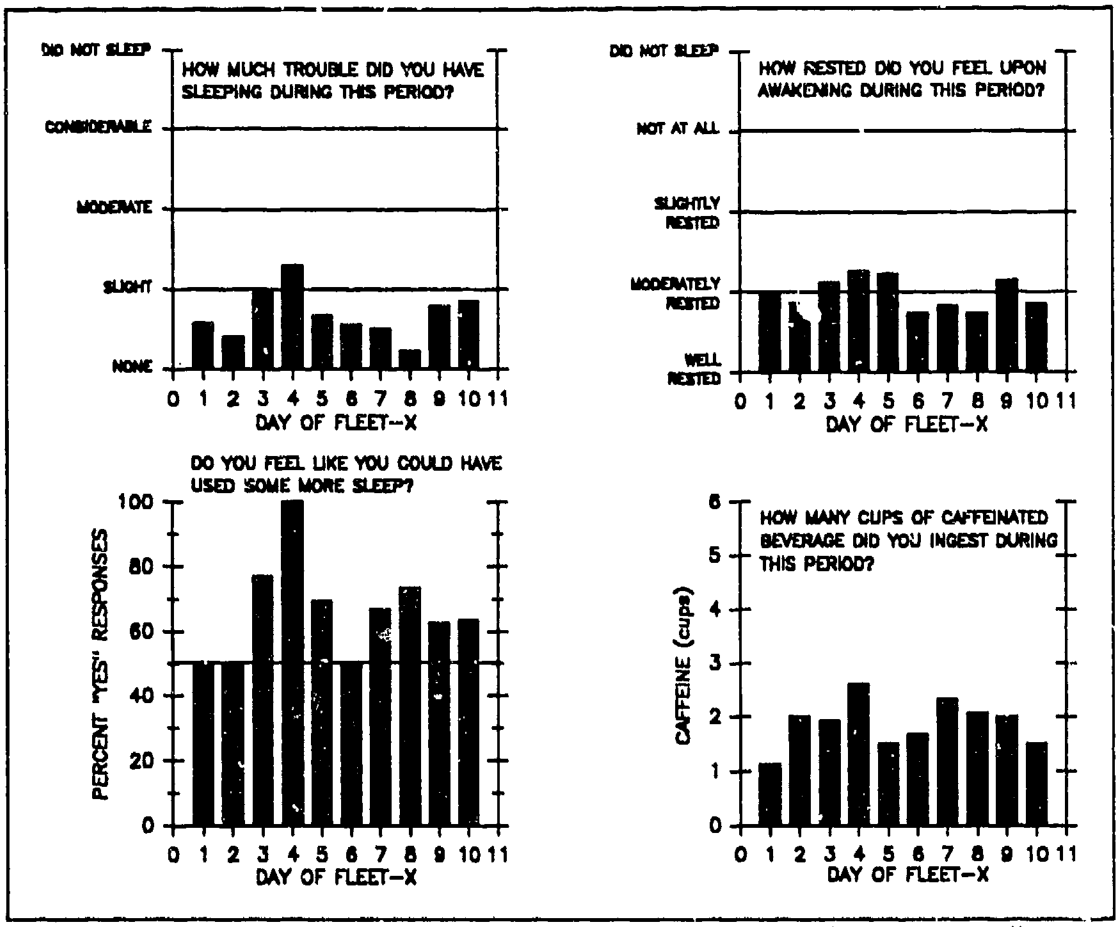


Figure 5. Average responses to four questions from the survey card relating to sleep quality and fatigue.

DISCUSSION

The activity survey data are consistent with numerous reports from aviators (and our own observations) that this fleet exercise was below average in difficulty and physical challenge. Figs. 3 and 4 show that aviators had ample opportunity for adequate sleep and rest. Flying, flight-related activities, and other tasking did not appear to cut deeply into normal sleep and rest time. As little as 4.5-5.5 h of sleep per 24 h is considered adequate to maintain acceptable levels of performance (Naitoh, 1989), although poor mood, lowered motivation, and general malaise may result. Average sleep duration during this exercise rarely approached levels this low.

The pattern of increasing delays in sleep onset from days 3-8 is a cause for some concern, particularly because aviators did not get to sleep until after 0300, on average, on day 8. A prolonged pattern such as this can ultimately lead to circadian desynchrony, sleep problems, and increased levels of fatigue. Nonetheless, the subjects' responses on the survey card (Fig. 5) did not indicate serious sleep problems. With the exception of day 4, subjects reported little trouble sleeping or the desire for more sleep, nor did they tend toward greater fatigue as the fleet exercise progressed. Still, more sleep problems may have developed if this pattern of delayed sleep onset continued.

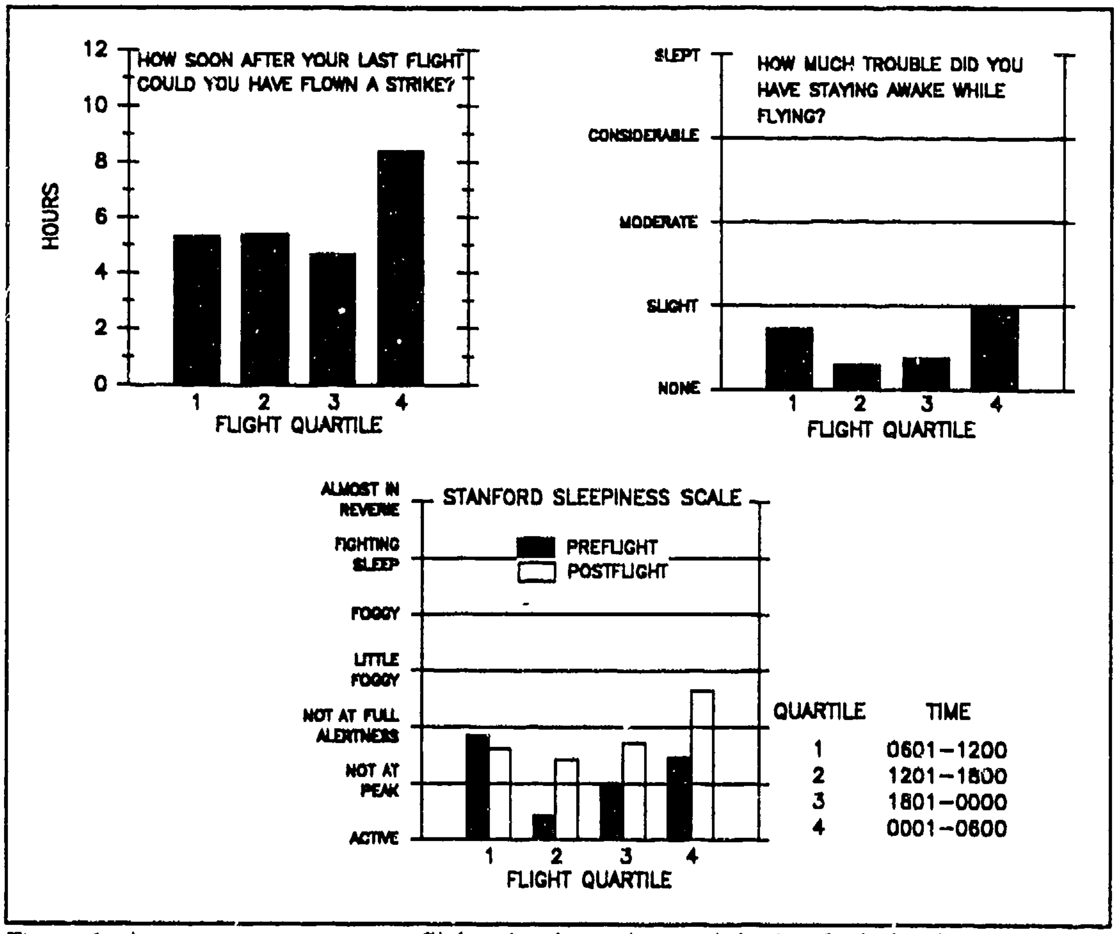


Figure 6. Average responses to two flight-related questions and the Stanford Sleepiness Scale as a function of time of day of the flight (flight quartile).

The SSD question (Figs. 6 and 7, top left panel) was designed to obtain an estimate of aircrew readiness after a mission. When plotted against flight quartile, SSD is consistent with that of Operation Desert Storm for A-6 and F-14 aviators (Shappell & Neri, 1992). The increase in strike delay observed during the 0001-0600 quartile coincides with the usual circadian trough, a time when the body's resources are at a daily low and sleep occurs. The average SSD was considerably more variable when plotted against the duration of the flight (Fig. 7). Two peaks indicating more than 8 h of required rest were noted following flights of 4.5 and 6 h. We expected that missions longer than 3 h would result in strike delays of 5 h or more. However, it is somewhat surprising that, for 5-h missions, SSD would decrease to the 4 h reported here. Most likely, some of the variation observed with flight duration is a function of mission type and time of day of the mission, in addition to flight duration. Nevertheless, these data indicate that even during a fleet exercise that was almost certainly less difficult than combat, S-3 aviators reported needing a minimum of 5-6 h rest after a flight before a strike mission could be flown.

The results from the question concerning trouble staying awake in the cockpit were also predictably consistent with circadian factors (Fig. 6, top right panel). During the two 6-h periods from 1201-0000 (Quartiles 2 & 3), when aviators reported the least trouble staying awake, there tends to be a general increase in performance on most cognitive tasks (Hockey, 1986). The increase in difficulty staying awake during flights from 0601-1200 is probably due to the fact that aircrew had to wake up at least several hours before launch.

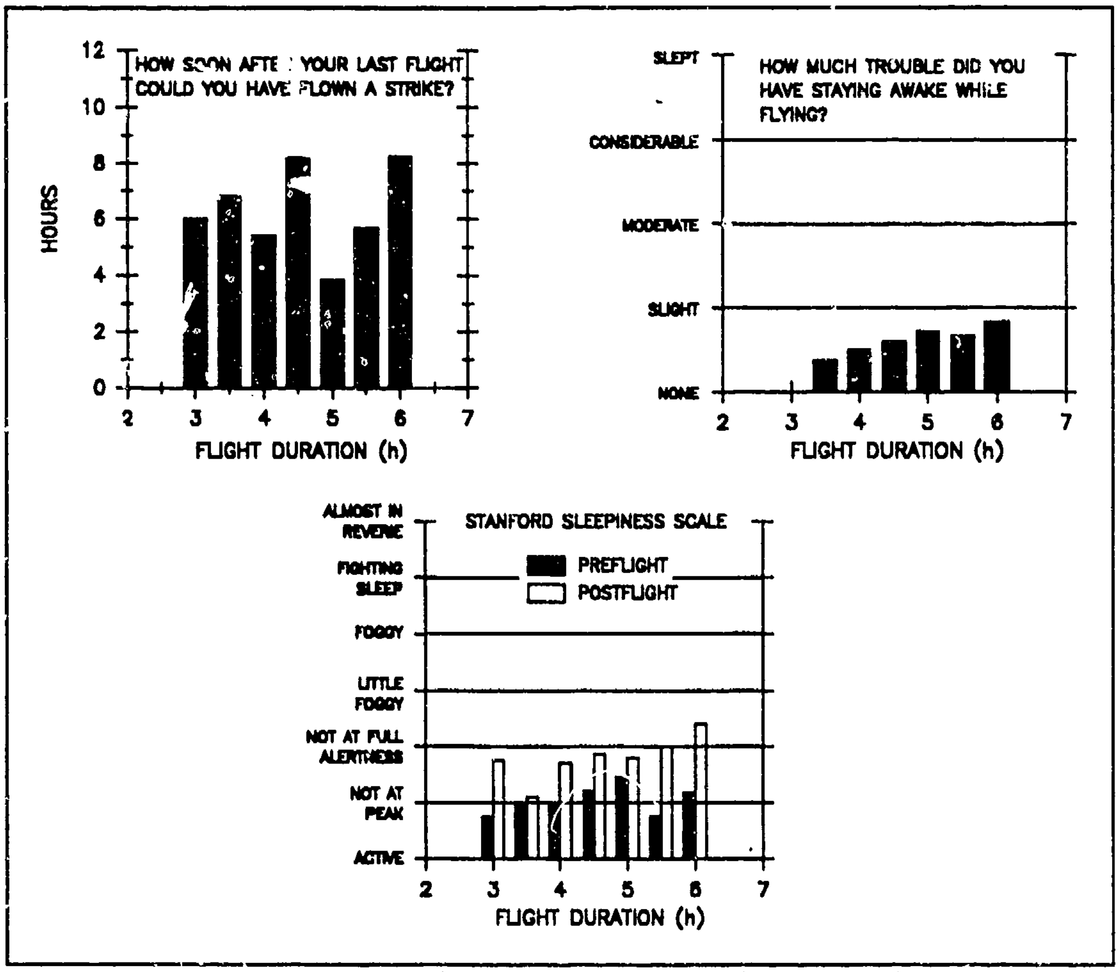


Figure 7. Average responses to two flight-related questions and the Stanford Sleepiness Scale as a function of flight duration.

This often resulted in wake-up times as early as 0400, when people are still ordinarily quite sleepy. The late night/early morning hours, when aviators reported the most trouble staying awake in the cockpit, encompass the circadian trough, so this result is expected. Even so, aviators reported only *slight* trouble at this time of day. The pattern of trouble staying awake while flying, as a function of flight duration (Fig. 7, top right panel), shows the expected increase in difficulty with increasing flight duration. However, as mentioned previously, these results may be confounded with such variables as mission type and the time of day that the flight occurred.

The SSS results were in the expected direction, with sleepiness increasing as flight quartile increased from afternoon through night (Fig. 6, bottom panel). The exception for morning flights may be due to aviators being sleepy from waking up early to fly during this period. This may account for the moderate levels of fatigue reported *before* the flight. The observation that subjects reported being slightly less sleepy after flying may be a reflection of late-morning aircraft recoveries and debriefs. This is a time when some of the improvement in vigilance and performance becomes evident (Hockey, 1986). The observation that aviators still reported that they were not at full alertness may reflect the influence of the mission on reported sleepiness. The consistent and significant increase in sleepiness postflight (relative to preflight) is evidence that the missions were fatiguing. Aircrew almost always finished a flight reporting that they were somewhere between *not at*

peak and *not at full alertness*. In fact, aviators landing aboard the carrier during the 0001 to 0600 quartile reported feeling between *not at full alertness* and *a little foggy*. This is clearly not a desirable situation.

The general trend of increasing sleepiness with increasing flight duration is again in the expected direction. The preflight to postflight differences, observed when the SSS data are plotted by quartile, are also present when the data are plotted by flight duration (Fig. 7, lower panel). As expected, aviators reported the highest levels of sleepiness following 6-h missions. Again, the sleepiness level postflight was between *not at full alertness* and *a little foggy*--a less than optimum situation. However, factors other than flight duration likely play a role. As stated earlier, mission type and time of day are probably related to sleepiness.

The sleep log/activity data described to this point are not surprising given the perceived level of difficulty of this fleet exercise. Several indicators of fatigue and sleepiness are related to operational tasking, but much of the variation may also be related to the time of day that missions were flown. This situation perhaps makes the performance data (Fig. 2) all the more interesting. Despite the fact that the fleet exercise was apparently not pushing the aviators to their limit, there were statistically significant performance changes from pre- to postflight on a reaction time task sensitive to fatigue and sleep loss. Although the changes were not large in magnitude, they were consistent enough to reach statistical significance. This result can be interpreted as a warning flag, suggesting replication with a larger number of subjects to support a conclusion of performance changes under these circumstances. The data also suggest that, if performance changes occur under these relatively benign conditions, then one might expect more serious problems under more challenging circumstances. Further research in this area is needed to determine the magnitude and extent of this problem. We recommend that additional data be collected on a variety of fleet exercises with particular effort made to include S-3 squadrons affected by the reductions in manning and the increased tasking. The additional data will provide an objective means of fully evaluating the impact of these operational changes on the S-3 community.

REFERENCES

Aerospace Medical Panel Working Group 12. (1989). *Human performance assessment methods.* (AGARDograph No. 308). Neuilly-sur-Seine, France: NATO Advisory Group for Aerospace Research and Development.

Angus, R. G., & Heslegrave, R. J. (1985). Effects of sleep loss on sustained cognitive performance during a command and control simulation. *Behavior Research Methods, Instruments, & Computers, 17*, 55-67.

Angus, R. G., Heslegrave, R. J., & Myles, W. S. (1985). Effects of prolonged sleep deprivation, with and without chronic physical exercise, on mood and performance. *Psychopharmacology, 22*, 276-282.

Anonymous, (1989). *The Almanac of United States Seapower, 1989-1990.* New York: Simon & Schuster, Inc.

Babkoff, H., Mikulincer, M., Caspy, T., Carasso, R. L., & Sing, H. (1989). The implications of sleep loss for circadian performance accuracy. *Work and Stress, 3*, 3-14.

Beare, A. N., Bondi, K. R., Biersner, R. J., & Naitoh, P. (1981). Work and rest on nuclear submarines. *Ergonomics, 24*, 593-610.

Brictson, C. A., Hagen, P. F., & Wulfeck, J. W. (1967). *Measures of carrier landing performance under combat conditions.* Santa Monica, CA: Dunlap and Associates, Inc.

DeJohn, C. A., Shappell, S. A., & Neri, D. F. (1992). *Subjective fatigue in A-6, F-14, and F/A-18 aircrews during Operations Desert Shield and Desert Storm* (Report No. 1377). Pensacola, FL: Naval Aerospace Medical Research Laboratory.

Haertzen, C. A. (1966). Development of scales based on patterns of drug effects, using the Addiction Research Center Inventory (ARCI). *Psychological Reports, 18*, 163-194.

Hartman, B. O., & Cantrell, G. K. (1967). *Mol: Crew performance on demanding work/rest schedules compounded by sleep deprivation* (Report No. SAM-TR-67-99). Brooks AFB, TX: USAF School of Aerospace Medicine.

Hockey, G. R. J. (1986). Changes in operator efficiency as a function of environmental stress, fatigue, and circadian rhythms. In K. R. Boff, L. Kaufman, & J. P. Thomas (Eds.), *Handbook of perception and human performance: Vol. II. Cognitive processes and performance* (pp. 44-1-44-49). New York: Wiley.

Hoddes, E., Dement, W. C., & Zarcone, V. (1971). The development and use of the Stanford Sleepiness Scale (SSS). *Psychophysiology, 9*, 150.

Mullaney, D. J., Kripke, D. F., & Fleck, P. A. (1983). Effects of sustained continuous performance on subjects working alone and in pairs. *Perceptual and Motor Skills, 57*, 819-832.

Mullaney, D. J., Kripke, D. F., Fleck, P. A., & Johnson, L. C. (1983). Sleep loss and nap effects on sustained continuous performance. *Psychophysiology, 20*, 643-651.

Naitoh, P. (1989). *Minimal sleep to maintain performance: Search for sleep quantum in sustained operations* (Report No. 89-49). San Diego, CA: Naval Health Research Center.

Naitoh, P., Banta, G., Kelly, T., Bower, J., & Burr, R. (1990). *Sleep logs: Measurement of individual and operational efficiency* (Report No. 90-29). San Diego, CA: Naval Health Research Center.

Neri, D. F., & Shappell, S. A. (1992). *The effect of combat on the work/rest schedules and fatigue of A-6 and F-14 aviators during Operation Desert Shield/Storm* (Report No. 1375). Pensacola, FL: Naval Aerospace Medical Research Laboratory.

Shappell, S. A., & Neri, D. F. (1992). *The effect of combat on aircrew subjective readiness and LSO grades during Operation Desert Shield/Storm* (Report No. 1369). Pensacola, FL: Naval Aerospace Medical Research Laboratory.

Shappell, S. A., & Neri, D. F. (in press). *Work/rest schedules and performance of F/A-18 aviators during Fleet Exercise 1992.* Pensacola, FL: Naval Aerospace Medical Research Laboratory.

Steele, T., Kobus, D., Banta, G., & Armstrong, C. (1989). *Sleep problems, health symptoms, and tension/anxiety and fatigue during wartime cruising in a moderately high heat/humidity environment* (Report No. 89-21). San Diego, CA: Naval Health Research Center.

Storm, W. F. (1980). *Aircrew fatigue during extended transport, tactical, and command post operations* (AGARD-CP-338). Neuilly-sur-Seine, France: Advisory Group for Aerospace Research & Development.

Other Related NAMRL Publications

Shappell, S. A., & Neri, D. F. (1992). *The effect of combat on aircrew subjective readiness and LSO grades during Operation Desert Shield/Storm* (Report No. 1369). Pensacola, FL: Naval Aerospace Medical Research Laboratory.

Neri, D. F., & Shappell, S. A. (1992). *The effect of combat on the work/rest schedules and fatigue of A-6 and F-14 aviators during Operation Desert Shield/Storm* (Report No. 1375). Pensacola, FL: Naval Aerospace Medical Research Laboratory.

DeJohn, C. A., Shappell, S. A., & Neri, D. F. (1992). *Subjective fatigue in A-6, F-14, and F/A-18 aircrews during Operations Desert Shield and Desert Storm* (Report No. 1377). Pensacola, FL: Naval Aerospace Medical Research Laboratory.

Shappell, S. A., & Neri, D. F. (in press). *Work/rest schedules and performance of F/A-18 aviators during Fleet Exercise 1992.* Pensacola, FL: Naval Aerospace Medical Research Laboratory.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
March 1993

3. REPORT TYPE AND DATES COVERED

4. TITLE AND SUBTITLE
Work/Rest Schedules and Performance of S-3 Aviators During Fleet Exercise 1992

5. FUNDING NUMBERS

6. AUTHOR(S)

David F. Neri and Scott A. Shappell

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Commanding Officer
NAVAEROMEDRSCHLAB
51 Hovey Road
Pensacola, FL 32508-1046

8. PERFORMING ORGANIZATION REPORT NUMBER
NAMRL- 1382

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Naval Medical Research and Development Command
National Naval Medical Center
Building 1, Tower 12
8901 Wisconsin Avenue
Bethesda, MD 20889-5606

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

We examined the effect that a fleet exercise has on the work/rest patterns, fatigue, and cognitive performance of S-3 aviators. For 10 days during Fleet Exercise 1992, 21 S-3 aviators from Carrier Air Wing Seventeen (CVW-17) aboard USS SARATOGA (CV-60) completed detailed daily-activity logs while performing their usual tasks. Subjective measures of fatigue, quality of rest, and sleep need were also collected. A subset of eight aviators completed a brief battery of computer tasks as soon as possible before flying and again after flight debrief. Results indicated that, although the fleet exercise appeared to be below average in difficulty, there were statistically significant performance changes from pre- to postflight on a fatigue-sensitive reaction time task. Average sleep onset was delayed over the course of the fleet exercise, peaking at past 0300 by day 8. A continuation of this pattern could lead to circadian desynchrony and serious sleep problems. Responses to questions on fatigue, sleep need, and readiness to fly a strike mission were consistent with circadian factors. Further research in this area is needed to determine the magnitude and extent of this problem. We recommend that additional data be collected on a variety of fleet exercises with particular effort made to include S-3 squadrons affected by the reductions in manning and increased tasking. The additional data will provide an objective means of fully evaluating the impact of these operational changes on the S-3 community.

14. SUBJECT TERMS
Circadian Factors, Cognitive Performance, Fatigue, Work/Rest Cycles

15. NUMBER OF PAGES
15

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	SAR

NSN 7540-01-280-5500

Standard Form 298 (Rev 2-89)
Prescribed by ANSI Std Z39-18
298-102